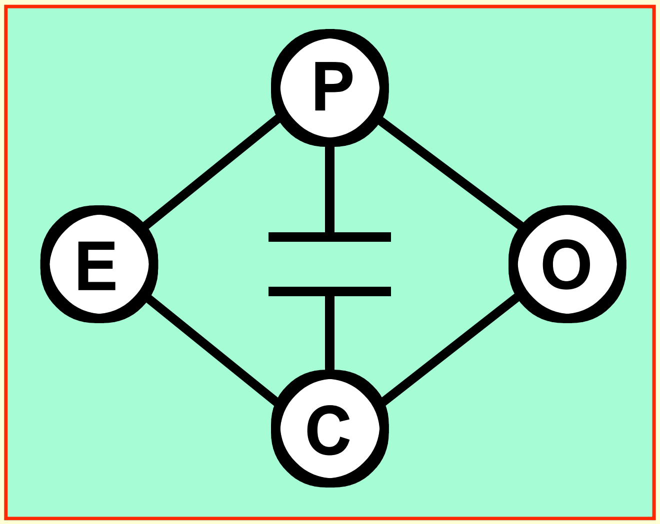
Stochastic Market Modelling

http://www.esc.auckland.ac.nz/Organisations/EPOC/index.html



Dr Geoff Pritchard

Types of models

physical

- e.g. SDDP

market behaviour

- equilibrium models
  - mutually stable strategies for players
  - e.g. Dublin

- stochastic models
  - distributions of behaviour; disequilibrium permitted
  - e.g. BOOMER

Data

Generators' offers are released after two weeks.

Public record covers 1/1/01-31/08/01, and 29/5/02-present.

CTCT,CYD2201,CYD,0,01/02/2003,24,420,3000,3000 189,.01,21,10,12,60,99,100,99,200, 31/01/2003 11:35:21,31/01/2003 11:36:58

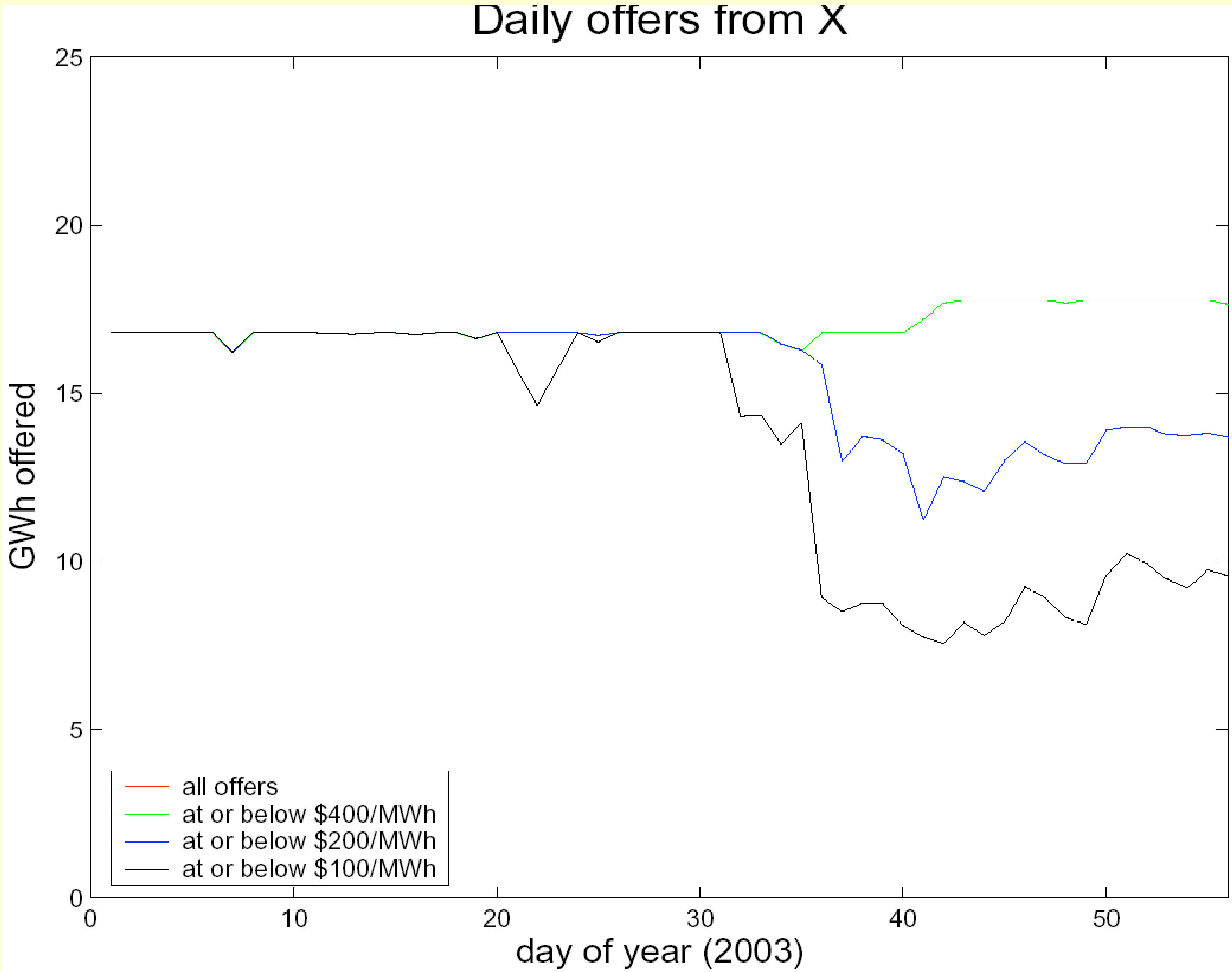
CTCT,CYD2201,CYD,0,01/02/2003,25,420,3000,3000 189,.01,21,10,12,60,99,100,99,200, 31/01/2003 11:35:21,31/01/2003 11:36:58

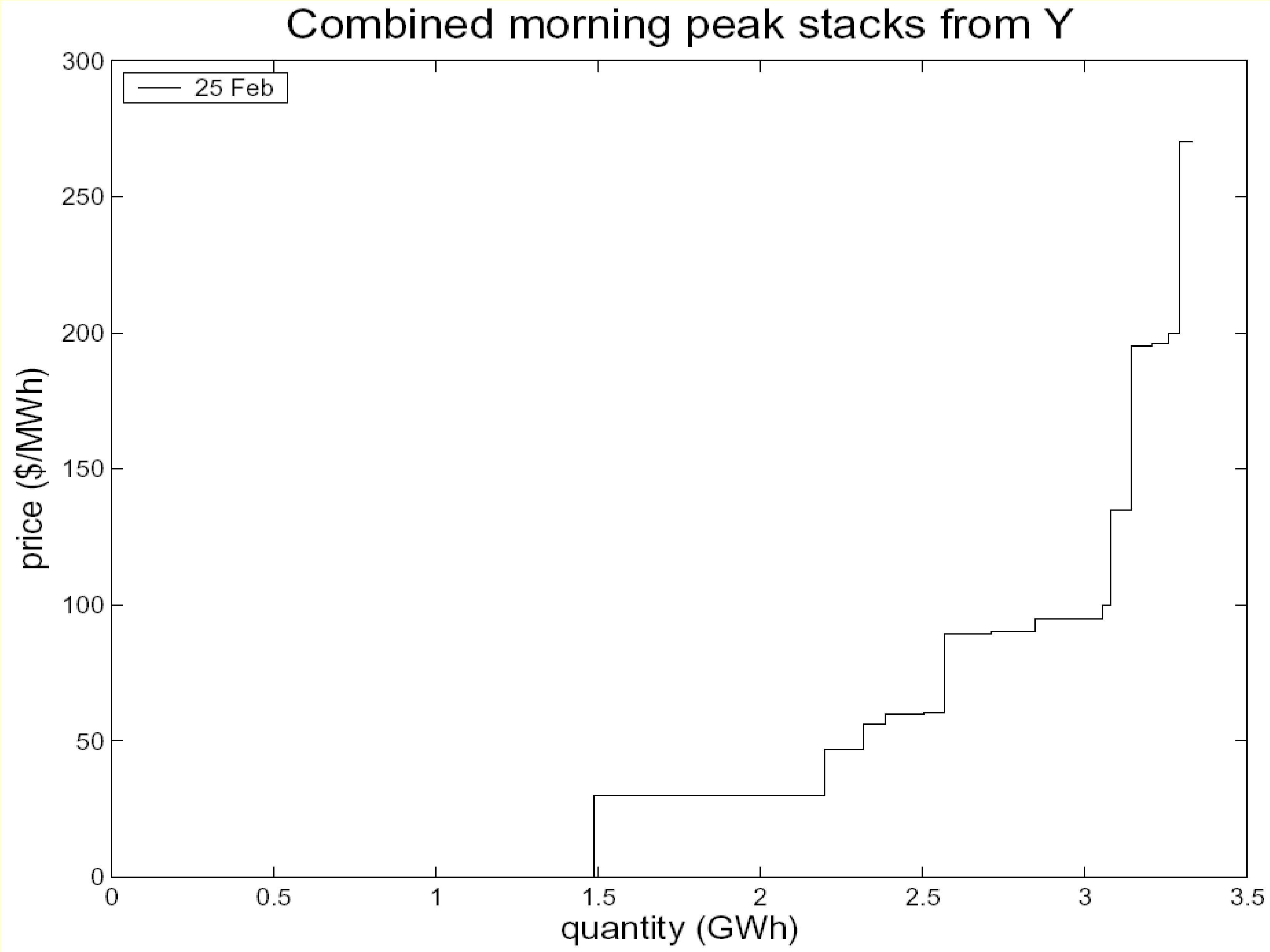
Can compare generators' actual behaviour with models.

BidQuery

(See: http://www.stat.auckland.ac.nz/~geoff/bidquery/)

Mines the database of past offering behaviour.

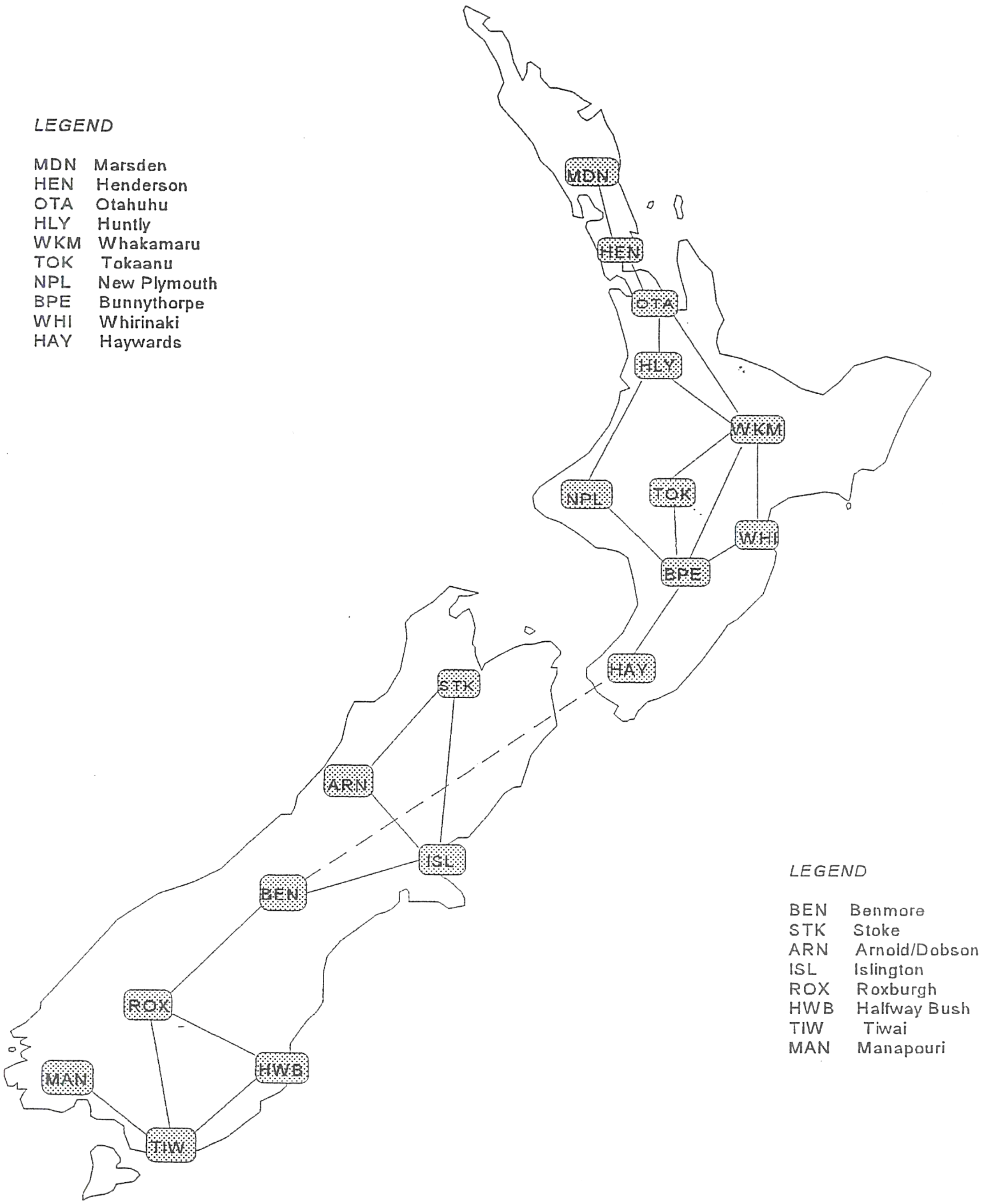

Daily offers from X
GWh offered
day of year (2003)
25
20
15
10
5
0
0
10
20
30
40
50
all offers
at or below $400/MWh
at or below $200/MWh
at or below $100/MWh


Combined morning peak stacks from Y
25 Feb
price ($/MWh)
300
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
3.5
quantity (GWh)

Problems 1 : historical reconstruction

“Predict the past” from knowledge of the offers made.

We use a simplified network (20 nodes) and BOOMER software.


LEGEND
MDN Marsden
HEN Henderson
OTA Otahuhu
HLY Huntly
WKM Whakamaru
TOK Tokaanu
NPL New Plymouth
BPE Bunnythorpe
WHI Whirinaki
HAY Haywards
MDN
HEN
OTA
HLY
WKM
NPL
TOK
WHI
BPE
HAY
STK
ARN
ISL
BEN
ROX
HWB
MAN
TIW
LEGEND
BEN Benmore
STK Stoke
ARN Arnold/Dobson
ISL Islington
ROX Roxburgh
HWB Halfway Bush
TIW Tiwai
MAN Manapouri

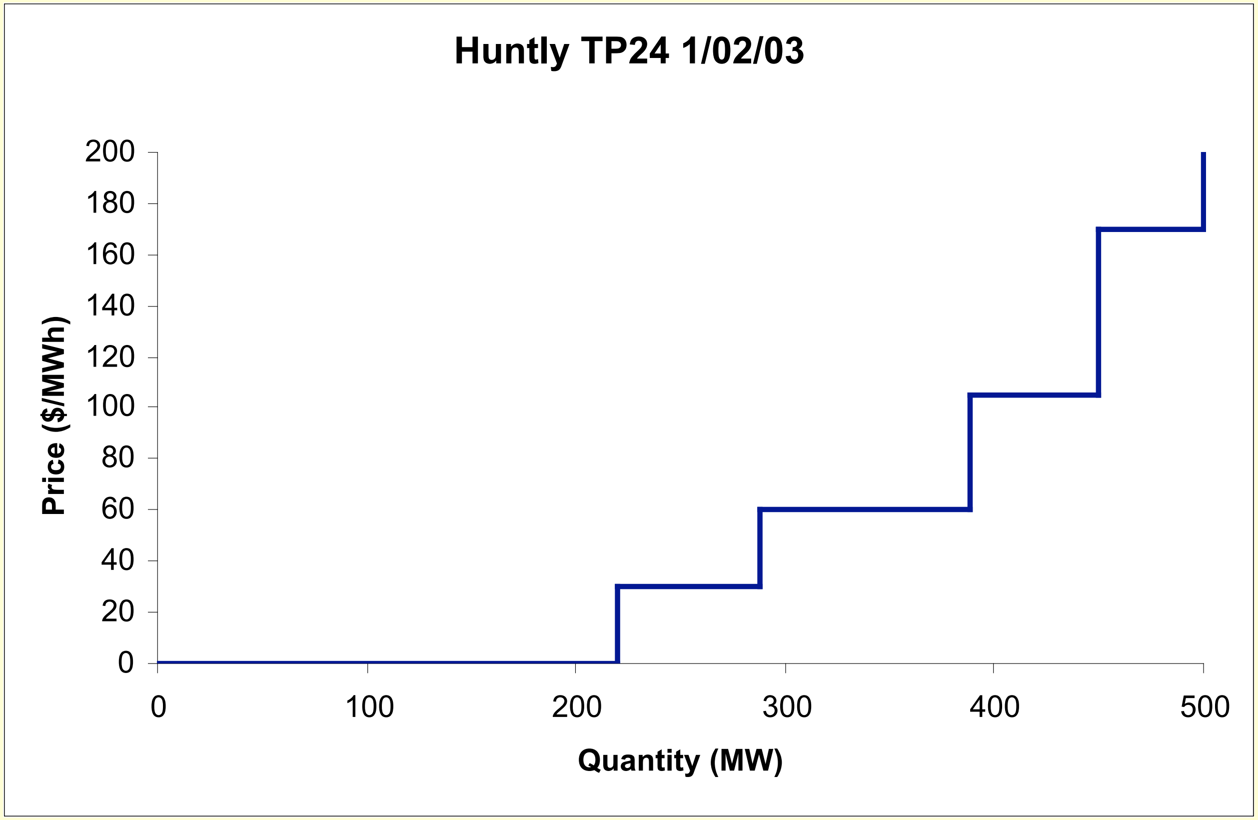
Example

period 24 (11:30-noon) on 1/2/03

node	actual price	modelled price
OTA2201	189.93	189.88
WKM2201	181.18	182.00
HAY2201	171.72	171.77
BEN2201	47.72	49.55
HWB2201	49.34	49.50

Problems 2 : optimal stacks

What stack “should” a particular generator have offered, to maximize profit?



Generator's objective function

Owner of Huntly might have wanted to maximize

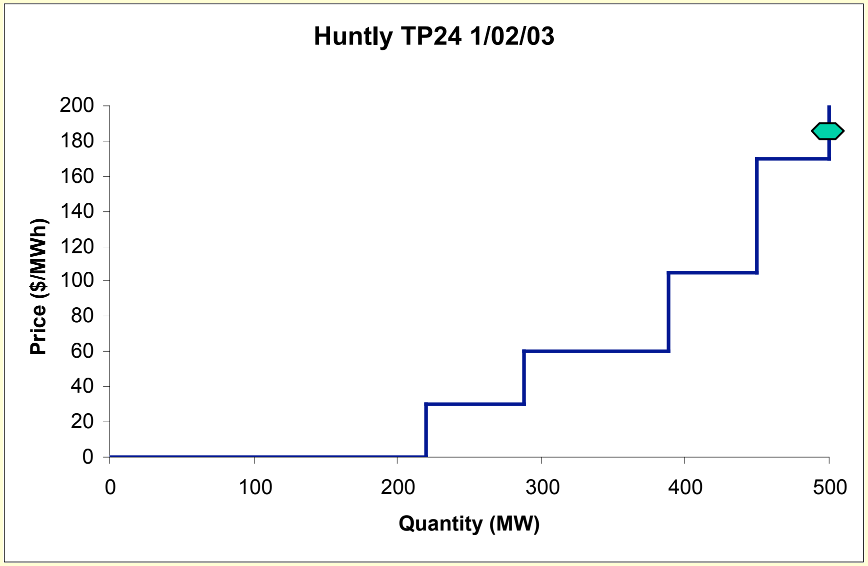
- revenue
  - HLY+TKU+RPO
- less generation cost
  - $35/MWh
- less cost of own retail loads
  - 10% market share at MDN, OTA, HND, WKM, HAY, ISL
- As modified by contracts for differences
  - 100MW each at OTA, HAY, ISL, HWB; all at $50/MWh.

(Numbers are illustrative only!)

Uncertainty

Loads and competing offers are uncertain.

Uncertainty is the reason why the whole stack – and not just one point - matters!



Modelling uncertainty

Scenarios for possible behaviour of each competitor can be culled from:

- public record of past offers made
- other sources

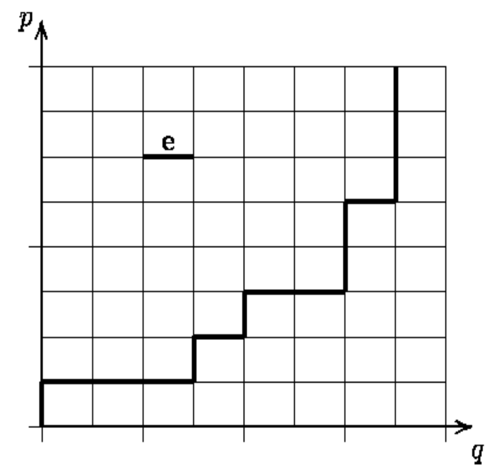
Loads can also be modelled statistically.

Optimization technique

Work with a pre-determined grid.

V(e) = expected payoff due to dispatches on edge e,
if e is included in the stack.
(Psi function)

Given V(e) for each edge, can find the stack that includes the most value.

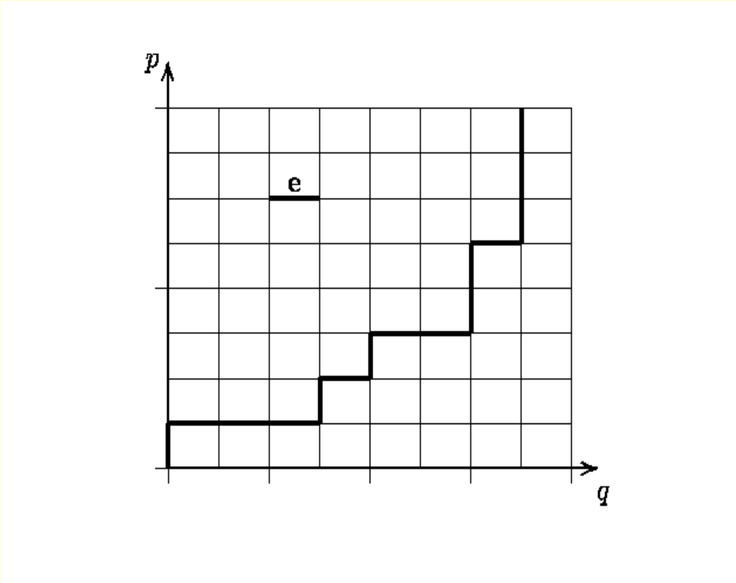


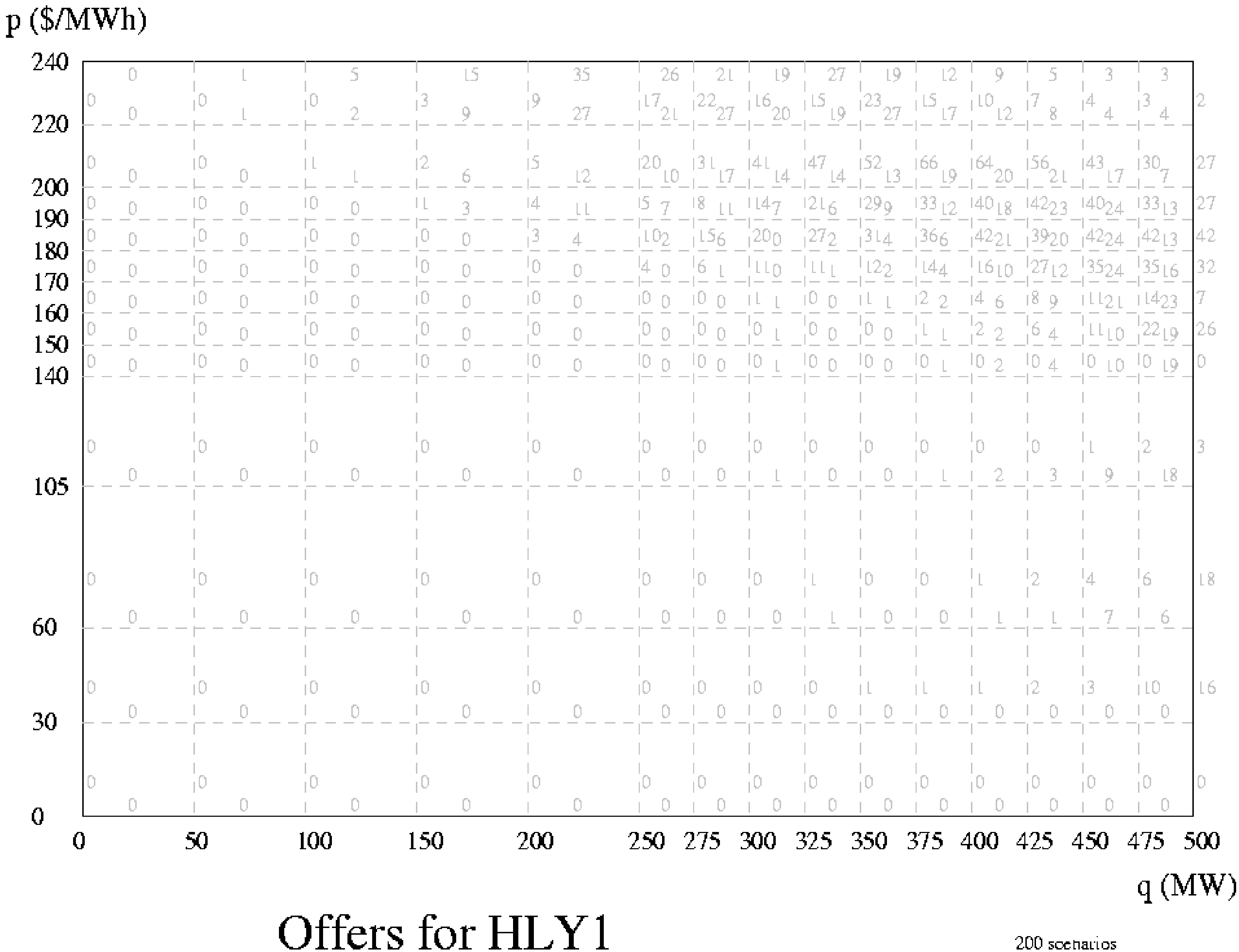
Edge values by simulation

Generate scenarios.

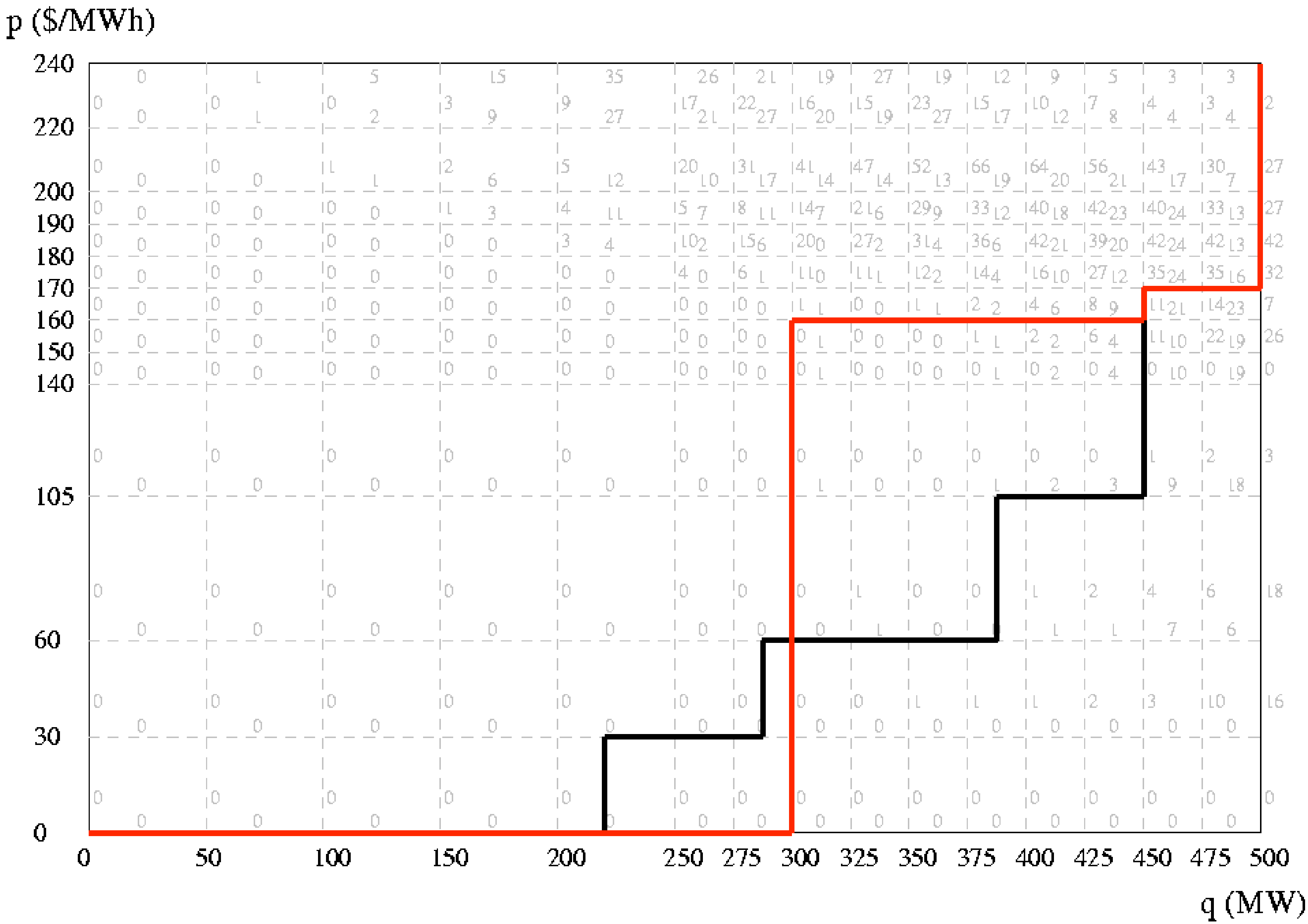
(antithetic sampling)

Estimate V(e) as the sample average payoff from dispatches on edge e.





Offers for HLY1



Offers for HLY1

200 scenarios
Value of stack 38682

Outcomes

Can obtain probability distributions for outcomes of interest, e.g. nodal prices

Price at node	mean	min	max
OTA	190.3	163.1	499.0
HLY	184.1	160.0	484.3
HAY	168.7	141.4	437.8
BEN	49.3	38.0	60.4

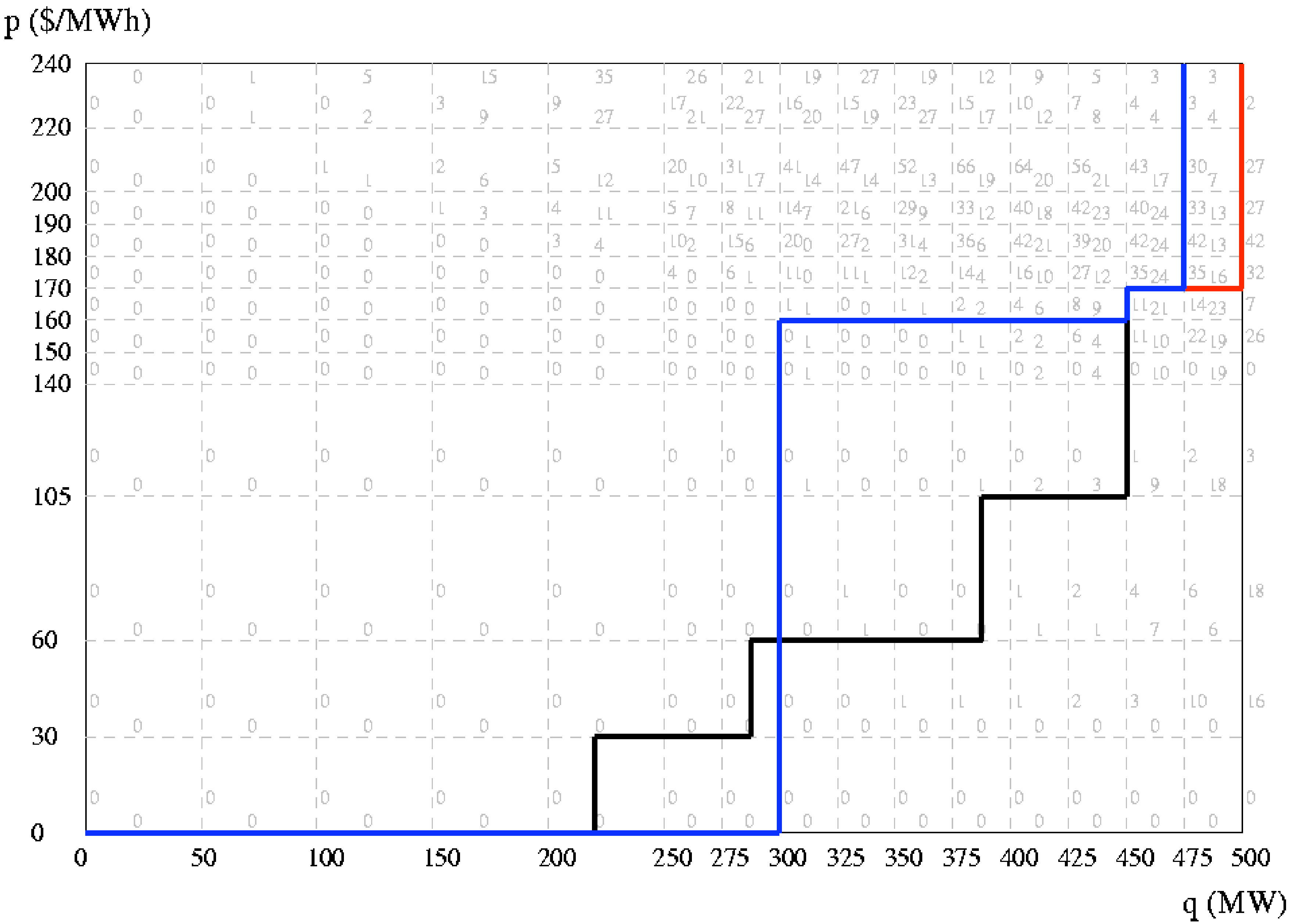
Security-constrained dispatch

Idea: in pursuit of 1-in-60 dry-year security, add a dispatch constraint like:

total hydro generation not more than H .

For our example try H = 2675 MW.

(This was satisfied historically, and in most scenarios in the model.)



Offers for HLY1

200 scenarios

Value of stack 38682

Hydro-security : outcomes

Prices increase in both islands.

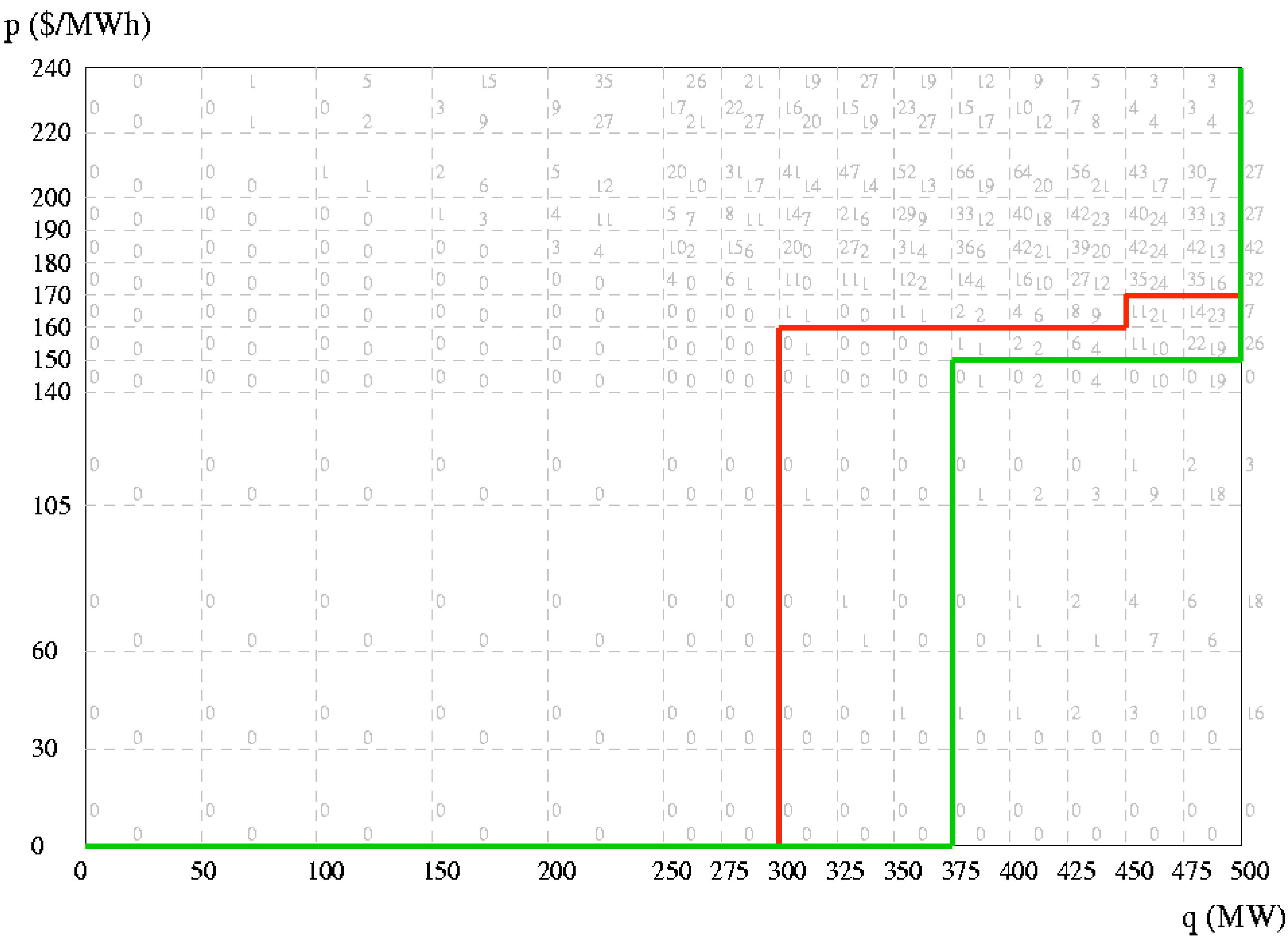
Price at node	mean	min	max
OTA	291.0	163.1	625.3
HLY	282.2	160.0	600.0
HAY	260.5	141.4	564.1
BEN	147.6	38.0	485.3

Hydro-firming contract

Idea: in pursuit of 1-in-60 dry-year security, give contracts that reward thermal output.

For our example try: $400/MWh penalty on shortfall from less than full dispatch at HLY.

(Historically, and in most scenarios in the model, no penalty would be payable.)



Offers for HLY1

200 scenarios
Value of stack 36502

Thermal contract : outcomes

Average prices decrease modestly.

Price at node	mean	min	max
OTA	185.2	51.0	499.0
HLY	179.1	49.5	484.3
HAY	164.2	44.8	437.8
BEN	49.2	38.0	60.4

Conclusions

A stochastic optimization model (BOOMER) can

- be quite detailed
- address specific historical situations
- suggest possible responses to changes in
  - behaviour of other players
  - market rules
  - generation / transmission capacity

End